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Agricultural Research

Nematodes: Good & Bad

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A New Way to Attack Complex Problems

Farmers and resource managers have been beset for many years by such diverse problems as the cotton yield barrier, gypsy moth destruction in the Northeast, and, in the West, overgrazing of rangeland and scarce water supplies.

Each of these problems, though separate in scope and location, is typified by its complexity. Only a few experts, for example, may possess the knowledge necessary to produce an exceptional cotton crop at the least cost. Specialists in several fields may each know enough to solve only a piece of the cotton puzzle. The difficulty in bringing knowledge and skill together on any complex subject and then distributing this information to all who need it is overwhelming.

Recent advances in computer technology should make better answers to complex problems available soon. In 1984, Agricultural Research Service purchased the first three *symbolic processing computers* in the U.S. Department of Agriculture. Programs called expert systems are now being designed for the new computers to help solve the cotton yield barrier and other perplexing problems.

Symbolic processing computers differ from the digital computers in that they use a data processing language made up of words, symbols, and figures instead of numbers alone. To solve a problem, they use all the knowledge that has been fed to them plus all the variable data at hand. They come up with an answer based on the best of several plausible solutions. This process mimics a human expert making decisions with facts, rules of thumb, and judgment based on training and experience. Sometimes symbolic processors are erroneously referred to as "thinking machines" because they can be programmed to "learn" from experience. They do this by adding data from each succeeding problem to their knowledge base.

Nonexperts should find it easy to use the expert systems once they are functional. The researchers involved in the project expect that access to most of the systems can be made with a personal computer from home or office.

The ARS expert system for simulating cotton production is located at Mississippi State, MS. It is designed to increase the understanding of cotton growth, pests, climatic factors, and associated interactions that account for cotton yield barriers.

When fully developed in cooperation with The Cotton Foundation, it is expected to help increase yields and cut costs to growers for a net increase in profitability of $30 per acre. With 10 million acres potentially able to be improved by use of the computerized expert system, projected savings could reach $300 million yearly. Growers will benefit by systematic development of important research knowledge bases. They may be able to tap the bases directly through the use of personal computers or through more conventional educational channels.

The ability to predict how much and how fast snow will melt to become water supplies is crucial, especially in the arid western states.

At Beltsville, MD, advanced computer simulation will handle a large volume of Western states water and climate data generated from remote weather stations, satellites, and other sources. Ninety percent of water for farming, hydropower, and drinking in the West comes from melting snow. If snowmelt forecasting can be made just 6 percent more accurate by using the planned expert system, the annual benefit could total $38 million per year for electric power generation and irrigation alone.

The expert system that simulates production and utilization of rangeland is also at Beltsville. This system will help ranchers get the highest possible livestock production without overgrazing the land.

There are about 200 million livestock animals on the range. Along with these, the range management expert system considers nearly 30 other variables, including soil types, weather, water supplies, and wild animals.

It is projected that a 1-percent improvement in range management, which is obtainable with better and more timely information, could save the beef industry over $230 million per year in the 17 Western states.

In Ithaca, NY, a symbolic processing computer and its expert system will provide insect control information to farmers, forestry officials, and research workers.

It has been estimated that the expert system can achieve a 1-percent improvement in the use of pathogens against gypsy moths. This would substantially cut damage to forests in the Northeastern states. A 2-percent improvement in Colorado potato beetle control would save $2.4 million in pesticide costs. In the 17 Western states there are over 40 million acres infested with grasshoppers annually to such an extent that they are causing economic damage. A reduction of 30 cents per acre in grasshopper control due to the expert system on insect pathogens would save about $6 million per year.—**L.E.M.**

Agricultural Research

Whiplike larva of root-knot nematode, *Meloidogyne incognita,* penetrates a tomato root. Once inside, the larva establishes a feeding site and causes nutrient-robbing galls to form on cells. As the larva consumes nutrients, the plant's growth is stunted. Magnified 1,800 times. Scanning electron micrograph, PN-7171, courtesy of William P. Wergin and Richard Sayre, ARS, Beltsville, MD. Story begins on page 10.

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Calcium Means Stronger Pears and Teeth

Calcium, known for its ability to build strong teeth and bones, also helps build strong plant cell walls and fight some pear diseases.

Studies by J. Thomas Raese, an Agricultural Research Service plant physiologist at Wenatchee, WA, show that increasing calcium in pears improves quality, lengthens storage life, reduces losses from diseases, and increases the amount of calcium available for human nutrition.

Raese says raising the calcium level in pears reduces the incidence of green stain, alfalfa greening or freckle pit, and cork spot disease, which occur during the growing season or in storage. These diseases can ruin up to 50 percent of a crop. They shorten the time pears can be stored by causing an ugly surface browning of the skin and soft, corky flesh inside.

Research on d'Anjou pears by Raese and colleagues Kenneth L. Olsen and Edward A. Stahly has led to four general ways growers can get more calcium into their pears—spray calcium directly on trees three or four times during the growing season, prune excess new growth early in the summer, apply less nitrogen fertilizer, and irrigate less.

Early pruning and moderate use of nitrogen fertilizer and irrigation reduce the fruit's competition with leaves and shoots for calcium, says Raese. This allows more calcium to enter and nourish the fruit.

According to Raese, "For the most part, pear growers could save money by using more calcium and less nitrogen fertilizer and irrigation water than they are now using."

"However," he says, "we are continuing our research to find the best rates and times of fertilizer application and more accurately determine the benefits of calcium as well as the effects on yield or size of the fruit."—**Howard Sherman**, Albany, CA.

J. Thomas Raese is at USDA-ARS, Tree Fruit Research Laboratory, 1104 North Western Avenue, Wenatchee, WA 98801. ■

Soybean Developed for Stable Oil

A new soybean breeding line may help to bring a long shelf life to salad dressings and cooking oils.

Off-flavors and objectionable odors that develop in aging soybean oil are associated with the breakdown of linolenic acid. The new breeding line, developed by Agricultural Research Service scientists at West Lafayette, IN, has about half as much linolenic acid as standard soybean varieties.

"By using the breeding line to develop new varieties for farmers to grow, we hope to reduce food processors' dependence on hydrogenation of soybean oil to preserve product freshness," says James R. Wilcox, a plant geneticist at West Lafayette.

Developed from a mutation of the 'Century' variety, the new soybean breeding line has a pair of recessive genes for the low linolenic acid characteristic that can readily be incorporated into other soybean varieties and breeding lines through backcrosses.

Wilcox and chemist James F. Cavins of the ARS Northern Regional Research Center at Peoria, IL, found that the mutant line, called C1640, is genetically stable and produces seed oil with about 3.5 percent linolenic acid content.

Oil in the standard Century variety has about 7 percent linolenic acid. The first generation of plants produced by a backcross between Century and the mutant line yields seed oil with about 6 percent linolenic acid.

The next generation from these seeds produces seeds that vary in linolenic acid content according to Mendel's law—one-fourth of the seeds had content similar to Century, one-half similar to the first generation, and one-fourth similar to the mutant line.

The low linolenic acid content in soybean oil that the scientists achieved through plant breeding is not much higher than the content in many commercially hydrogenated soybean oil products.

It may not be possible to breed soybeans devoid of this unsaturated fatty acid, Wilcox says. Even if it were possible, it would be undesirable because some linolenic acid is essential in human and animal nutrition.—**Ben Hardin**, Peoria, IL.

James R. Wilcox is in USDA-ARS Plant Science Research, Lilly Hall of Life Sciences Building, Purdue University, West Lafayette, IN 47907. ■

Sumac: A Possible Crop for Industry

Smooth sumac, a perennial shrub of the eastern United States, could be the next raw material for plastics, resins, and other manufactured substances. The milky sap of this nonpoisonous sumac contains oils, hydrocarbons, and polyphenol compounds that are of value as industrial feedstocks, says Agricultural Research Service agronomist T. Austin Campbell.

"Growing and harvesting sumac is fairly easy," says Campbell. "A farmer could grow a substantial crop, cut it, bale it, and send it to a processing plant where the polyphenols and oils would be removed."

Natural stands of sumac, *Rhus glabra,* produce 0.2 percent waxlike hydrocarbons, 5.5 percent oils similar to fatty acids, and 18.8

Agronomist T. Austin Campbell inspects a roadside stand of smooth sumac. (0685X604-20)

percent polyphenols, complex molecules that are used to make synthetic resins, according to Campbell, who is researching crops for potential new uses.

Sumac's percentage of polyphenols is extremely high as compared with most plants, he says. "Polyphenols may be the most important constituent of sumac."

He says polyphenols are used as the molecular "glue" that holds together slow-release drugs, pesticides, or solvents, slowly diffusing them into the environment. Slow-release compounds are used in medicine, for example, for long-term chemotherapy or in crop production to reduce labor costs of applying fertilizers.

Another use of polyphenols is as tannin to soften hides in making leather.

Campbell has found that sumac leaves contain more polyphenols and oil when the plant is in full flower, and that stems have more of both chemicals and hydrocarbons when the plant is in the seed-set stage.—**Deborah Aksler**, Beltsville, MD.

T. Austin Campbell is located at the USDA-ARS Germplasm Resources Laboratory, Beltsville Agricultural Research Center, Beltsville, MD 20705. ■

Crude Vaccine Is First Step Toward New Cattle Grub Control

A crude vaccine prepared from groundup larvae of the common cattle grub gives yearling calves resistance to this pest.

John H. Pruett, Jr., an Agricultural Research Service microbiologist at Kerrville, TX, tested the preparation on calves that had never been exposed to the grubs. He reasoned that the vaccine might give the calves the same level of resistance older cattle get through grub infestations.

And he was right.

The grubs are the larvae of honey bee-sized flies known by many names including gadflies, heel flies, and warble flies. The female fly usually lays her eggs on hairs around the hocks or heels of cattle legs. When the eggs hatch, the larvae crawl down the hairs and penetrate the animal's skin. They take 2 to 6 weeks to move to the esophagus, where they spend the summer and grow.

The larvae then migrate again, until they arrive just beneath the skin in the middle of the cow's back. There they secrete an enzyme that helps them form breathing holes through the hide. The holes damage the choicest part of the hide.

After opening the hole through the skin, the grub molts to a second stage and becomes encysted under the hole, forming ugly swellings called warbles. The meat near the warbles must be cut away and discarded when the animal is slaughtered.

Damaging the beef and hides is the primary but not the only reason cattle grubs cause losses of about 300 million dollars each year in the United States. For example, the vicious attacks of the flies cause cattle to run wild or "gad," disrupting their development, possibly even reproduction.

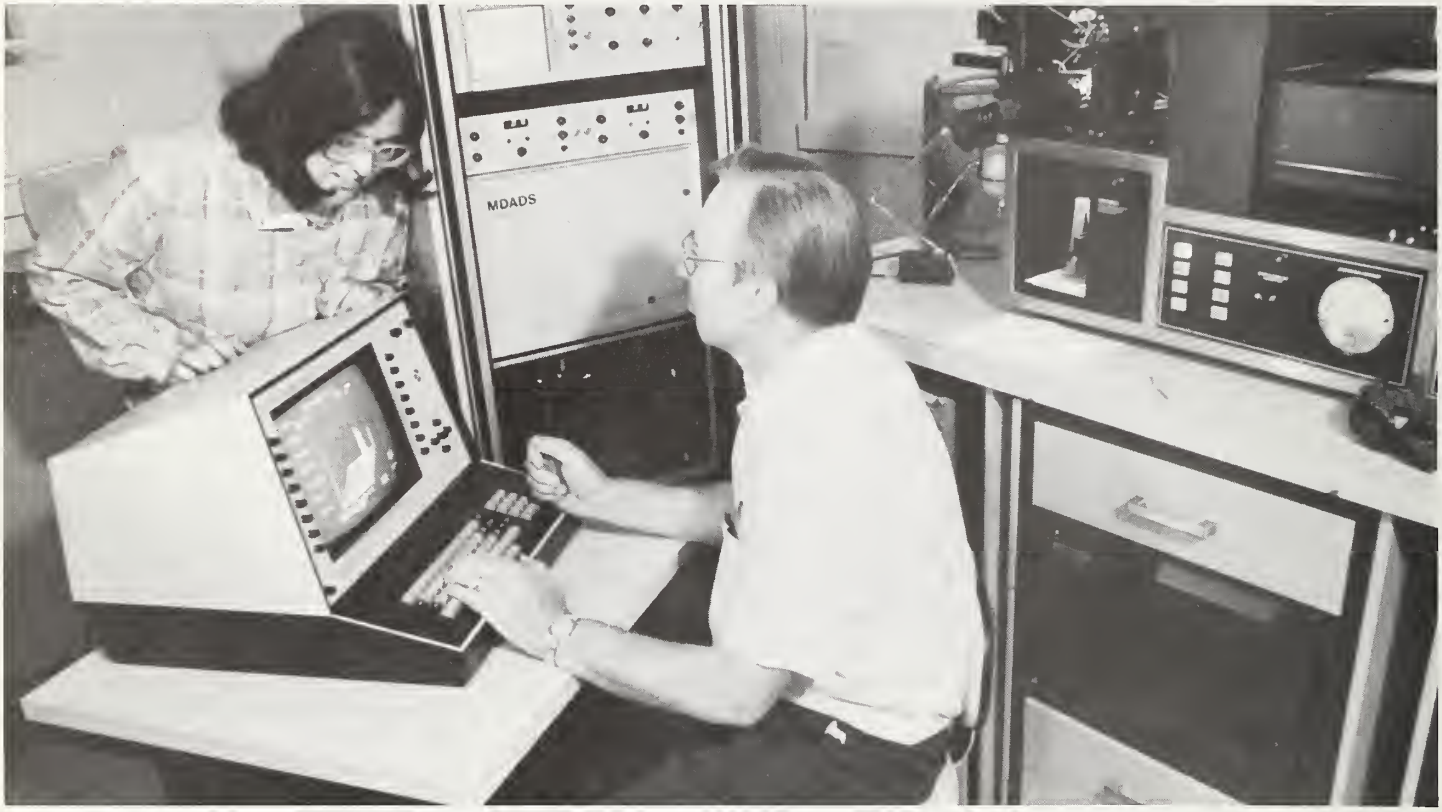
Pruett says the next step in the development of a pure cattle grub vaccine "is to isolate the antigen or antigens (proteins) that elicit the protective immune response. After we have done that, we hope to clone the antigen gene in bacteria."

If proven effective, a vaccine could replace chemical controls, which are expensive, time consuming, and potentially hazardous.

Pruett's research has been slowed by the absence of techniques and facilities for rearing heel flies and larvae in the laboratory. Until he develops such techniques, Pruett must collect grown larvae each August from infected cattle that have been slaughtered.—**Bennett Carriere**, New Orleans, LA.

John H. Pruett, Jr., is in Biting Fly and Cattle Grub Research, USDA-ARS U.S. Livestock Insects Laboratory, P.O. Box 232, Kerrville, TX 78028. ■

Selecting the Sex of Livestock Offspring



Animal physiologist Lawrence Johnson and research assistant Mary Look at console of a flow cytometer—an advanced cell sorter with a laser. (0485X369-8)

The sperm cells flow in a very fine, steady stream, down through the blue light of a laser beam, past an electrical field, and finally into one of two test tubes, depending on which sex-determining chromosome the sperm has.

This sperm cell sorting technique, separating sperm with Y chromosomes (male) from those with X chromosomes (female), brings closer the day when livestock breeders will be able to choose an animal's sex before conception.

Being able to specify male or female offspring should dramatically shorten the time required for genetic improvements. Since desirable traits are often best carried through one or the other parent, breeders should be able to increase the efficiency of livestock production at a faster pace.

There are other benefits, too. If farmers could choose the sex of livestock, dairy farmers would produce only enough female calves to replace older cows. Beef and sheep farmers could produce males only, since they gain weight faster than females. For hog farmers, it would be the reverse, because female pigs grow faster than the males.

Two years ago, Lawrence Johnson, an animal physiologist for the Agricultural Research Service in Beltsville, MD, began using a recently developed instrument called a flow cytometer/cell sorter to analyze and separate sperm cells by whether they contain X or Y chromosomes. Since the machine was designed for use with blood cells, Johnson and his collaborator on the project, Dan Pinkel of Lawrence Livermore National Laboratories in Livermore, CA, had to modify it to analyze and sort sperm cells.

Before sperm cells are injected into the flow chamber of the cytometer, they are chemically treated to remove their membranes and tails. This renders them immobile, but allows their DNA (deoxyribonucleic acid) to be chemically stained. A fluorescent dye used as a stain causes the DNA in the now "naked" sperm cells to glow when exposed to a laser beam.

The naked sperm are injected into a small plastic chamber and then flow in a fine stream through a laser beam. Since X chromosomes have more DNA than Y chromosomes, they glow brighter, and the cytometer, connected to a computer, records the amount of fluorescence per sperm cell.

Once the sperm passes the laser beam, the sorting begins. The flow chamber is vibrated so it breaks the stream into microscopic droplets, each containing one sperm head. The droplets are given weak positive or negative charges depending on whether they have X or Y chromosomes. The drops then fall through an electrical field which pulls the

positive- and negative-charged sperm heads away from one another and into different containers.

In their sorting experiments to date, the scientists have used only chinchilla sperm, which are easier to sort because they have a much greater difference in DNA content between X and Y sperm than livestock sperm.

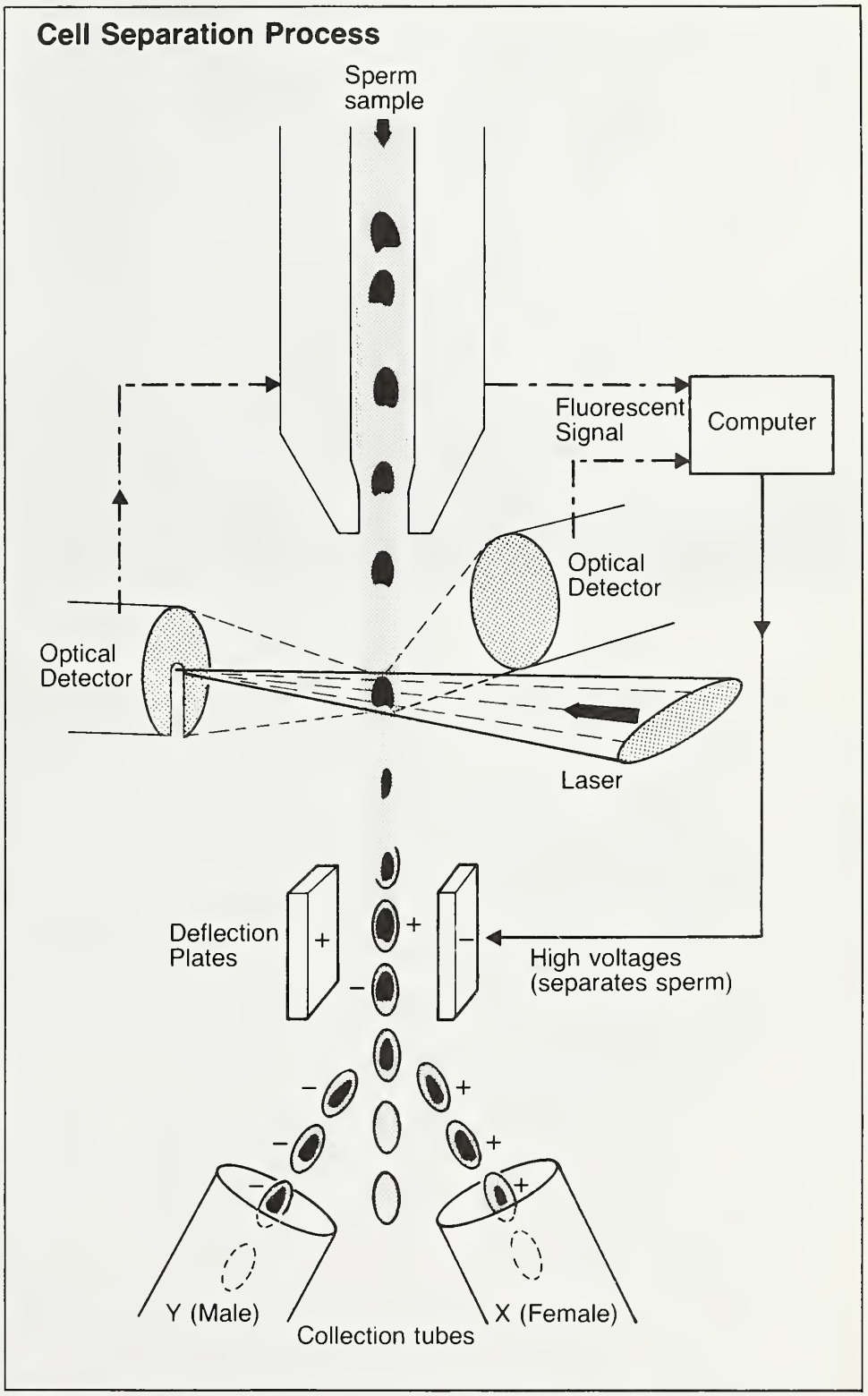
Johnson says that sperm cells sorted this way cannot be used for routine artificial insemination because they lack their tails and membranes, making it impossible for them to move and fertilize an egg on their own.

However, new knowledge gained from these experiments is expected to lead to the development of reliable systems for preselection of sex in livestock, Johnson says. That day may be some years away though because—overlooking the fact that the sexed sperm cells are immobile—sorting by DNA content is too time-consuming to be practical for livestock breeders. Johnson says he and his colleagues (including research assistants James Flook and Mary Look, as well as Pinkel) are trying not only to make it possible to use whole sperm cells for sorting, but also to separate X and Y sperm based on something other than DNA.

Johnson says the only practical use for their technique at this time is the measurement of sperm sex ratios in samples of livestock semen sold with the claim of having a higher proportion of male or female sperm. In all samples tested so far, sperm sex ratios have equaled Mother Nature's 50:50 ratio.

Johnson says their work is laying the foundation for a sex-selection technique that may save the livestock industry several hundred million dollars a year through increased efficiency.—**Vince Mazzola** and **Donald Comis**, Beltsville, MD.

Lawrence Johnson, James Flook, and Mary Look are at the USDA-ARS Reproduction Laboratory, Building 200, Room 22, BARC-East, Beltsville, MD 20705. ■



Sperm nuclei are injected into flow cytometer/cell sorter. As sperm nuclei flow through the chamber, laser light excites the fluorescent dye previously added to the sperm. Each droplet containing sperm nuclei is given a positive or negative charge from the computer depending upon the quantity of DNA. The charged droplets are then drawn into separate tubes after passing through a high-voltage field. (PN-7156)

Computer Uses Logic and Math To Help Nonexperts

Using a computer programmed with artificial intelligence, soil scientist Jerry Ritchie and computer specialist Jan Thurman study runoff from snowmelt. (0485X367-12A)

A computer that can "think" will soon help manage the nation's water and rangelands.

In order to save these precious resources, scientists in the Agricultural Research Service are developing sophisticated computer programs that use elementary logic as well as mathematics to solve management problems. Computers that employ a combination of symbols, words, and math are known as artificial intelligence processors—AI for short.

Hydrologist Ted Engman, with ARS in Beltsville, MD, is designing an artificial-intelligence program for predicting runoff from snowmelt. Using the same computer, soil scientist Jerry Ritchie is building a program to determine the effects of grazing on range ecosystems.

"We are turning to AI because both range and water resources depend on careful management," says Engman. Ninety percent of water for farming, hydropower, and drinking in the Western states comes from snow melting in the spring.

The type of AI program to be used is an "expert system," which mimics decisionmaking processes of human experts. To solve a problem, a human expert makes decisions based on training and experience, often using heuristics, or rules of thumb. Expert systems are based on information supplied by specialists in the field, such as hydrologists and geologists.

Both water and range management expert systems will be added to existing computer models to make them more adaptable, providing expertise to the nonexpert who does not have years of experience in the field.

Making the Most of Snow

Engman's program, called the Expert System Snow Runoff Model (EXSRM), is the nation's first artificial-intelligence program for water management.

Since water is so important for life, the ability to predict how much and how fast snow will melt to become water supplies is crucial, especially in the arid Western states, says Engman.

Prior to computers, hydrologists used graphs of snowfall and melt records to try to predict spring runoff, Engman says. Graphic predictions worked to a degree, but in more recent years computers have helped make predictions more accurate and more timely. Now, hydrologists use data gathered from field surveys and automatic gauges to make predictions of snowmelt.

With the EXSRM system, hydrologists can consider more complex data such as actual snowfall, slope and elevation of terrain, temperature changes, and remote-sensing data from satellites. The system will also help hydrologists monitor how recent predictions compare with up-to-the-minute conditions, in order to adjust new predictions.

With the new system, a hydrologist can project unknowns like the amount of melt in June that will come from February snow cover. "Although we have already developed good water-management programs with the available models," Engman says, "the EXSRM can ensure that they are based on the best possible information."

Engman describes the programming as "slowgoing, but fun." He hopes that within a year the EXSRM will be able to guide anyone through most of the steps of determining runoff from the winter snowpack.

Making the Most of Grasslands

Ritchie is developing EXSPUR—the Expert System Simulation of Production and Utilization of Rangeland. The system will help ranchers get the highest possible livestock production without overgrazing the land. This is already a major problem, however, in that 50 to 70 percent of the nearly 5 billion acres of rangeland is already overgrazed, according to Ritchie.

To improve their land, ranchers need to control the number of cattle or sheep on the land, since overgrazing allows unpalatable sagebrush to grow. Better grasses will reduce erosion and improve the condition of the range in general.

With the indepth scenarios the computer can create, a range manager could determine, for example, whether 800 cows will overgraze a section or 200 would undergraze it. There are about 200 million livestock

In mountainous northwest Idaho, a hydrologist uses a snow tube to measure the depth and density of a snowfield. Computer modeling will eventually reduce the necessity for most such field sampling. (0675X802-29)

animals on the range. "A 1-percent improvement in the land, which is do-able, could save the beef industry $234 million per year in the 17 Western states," Ritchie says.

Prior to computer models, rangeland managers made educated guesses, based on conditions at the end of the year, of the number of animals that a particular piece of land could support. There are a great number of factors that affect the range and thus grazing. The EXSPUR system includes 30 variables, such as soil type, climate, water, vegetation, and animals, both livestock and wild species. "We're trying to design a program so a range manager won't have to know everything about all of the variables," says Ritchie.

He says the program will take 1-to-2 years to get it to the point where a nonexpert could use it. "It seems to have a lot of potential," Ritchie says.

Expert Systems Imitate Human Decisionmaking

An expert system is a type of artificial-intelligence program that follows a few general procedures for solving problems. It uses facts, "experience," and models stored in the computer's memory by human experts.

There are two ways the computer can arrive at conclusions. It can reason forward, going from facts to a solution, or work backwards from a hypothetical solution to find supporting evidence.

Using the two reasoning approaches to solve a particular problem, the computer suggests a set of hypotheses based on data input by a user, such as a resource manager. The system then considers each hypothesis in turn, attempting to find a specific solution. The AI programs break down decisions like the ones the user goes through. It can interpret the correct meanings from context or ask appropriate questions. Thus the computer imitates humans who often reach conclusions from partial or uncertain evidence by following possible lines of reasoning.

But perhaps the most significant fact is that the system itself can learn. "There is always room for additions to the system as it builds up its own data base of experience," Engman explains. For example, if a hydrologist has used the same type of data for 5 years and then inputs an odd variation, the computer would recognize the difference, and ask if the data is correct.

To develop their expert systems, both scientists use a new computer at Beltsville that has some unique aspects. The symbolic processing language it uses, called LISP, can represent virtually any type of object. It is designed to handle words and symbols, a kind of shorthand for the computer. Engman says that a regular digital computer could make the snowmelt predictions, but it can not help a nonexpert make more accurate predictions.

Another unique aspect of the computer is its ability to produce simple graphs or three-dimensional color graphics. "The graphs are valuable for long-term planning, very important in resource management," says Ritchie.—**Deborah Aksler**, Beltsville, MD.

Ted Engman and Jerry Ritchie are located at the USDA-ARS Hydrology Laboratory, Beltsville Agricultural Research Center, Beltsville, MD 20705. ■

Nematodes:

Above: With thousands of species, it is often difficult to tell one nematode from another. Variations in male mating structures, called spicules, help scientists distinguish harmful species of nematodes from beneficial ones. The spicule (center) identifies the species as *Bursaphelenchus xylophilus,* a destructive pinewood nematode. Magnified 5,000 times. Scanning electron micrograph (SEM) courtesy of William P. Wergin and W. R. Nickle, ARS, Beltsville, MD. (PN-7173)

Right top. What looks like an animal's head is actually the tail of a nematode, *Trichinella spiralis,* magnified 2,500 times. The larval stage of this nematode occurs in the muscles of swine and can cause trichinosis in people unless pork is cooked. SEM courtesy of J. R. Lichtenfels and Norita Chaney, ARS, Beltsville, MD. (PN-7170)

The Good, the Bad, and the Ugly

Nematodes, also called eelworms, pinworms, threadworms, and roundworms, are as common on this planet as rocks. Numbering 13,000 species, they live in every square foot of the Earth's soil from the Arctic to Antarctic and in fresh and salt waters. Several can even live in vinegar.

Their range in size is as great as for any class of life on Earth. The smallest measure only one hundredth of an inch; the largest, found in whales, are 27 feet long.

Some nematodes are parasitic. "All living things—plants, insects, animals, man—are susceptible to nematode infection," says Howard E. Waterworth, who coordinates national research on nematodes for the Agricultural Research Service.

Many species, he says, cause serious diseases, including trichinosis in man and roundworm in dogs and cats. On plants, two of the most destructive are the golden nematode that favors potatoes and the root-knot nematode that attacks most vegetables. Overall, the toll nematodes take on U.S. crops is about 7 billion dollars yearly— only slightly behind the loss from insects.

Some species of nematodes, Waterworth added, are beneficial or at least do no harm. Only about 5 percent damage plants and harm animals.

Nematodes are extremely prolific—90,000 were found in a single rotting apple; 36 species totaling 1,074 were counted in only a thimbleful of mud; and 3 to 9 billion an acre may be found in good U.S. farmland.—**Hank Becker** and **Hubert Kelley**, Beltsville, MD.

Scanning eletron microscope magnifies nematode egg thousands of times with 3-D effect, permitting scientists to study nematode anatomy. Using the microscope are William P. Wergin, head of ARS' Electron Microscopy Unit, Beltsville, MD, and biologist/scanning microscopist Norita Chaney. (0585X389-19A)

Howard E. Waterworth is National Program Leader for Plant Health, Beltsville Agricultural Research Center, Bldg. 005, Beltsville, MD 20705. ■

Left middle: a bacterial spore, *Pasteuria ramosa,* attaches itself to a root-knot nematode, a plant parasite. When the spore germinates, it will kill its host. ARS scientists at Beltsville, MD, are studying this bacterium and others with potential for controlling destructive nematodes. Magnified 2,400 times. SEM courtesy of Wergin and Richard Sayre, ARS, Beltsville, MD. (PN-7172)

Left bottom: Like a hypodermic needle, a stylet, which can be projected from the head of parasitic plant nematodes, injects liquids into cells and draws nutrients from plant roots. Found on grape roots, this root-knot nematode, *Meloidogyne nataliei,* is magnified 7,500 times. SEM by A. Golden, ARS, Beltsville, MD. (PN-7174)

Potato Nematode May Be Tricked Into Self-Annihilation

A chemical substance found in potato roots may someday be synthesized to send false hatching signals to eelworm eggs lying in unplanted fields, duping the worms into emergence and starvation.

Eelworms, also known as golden nematodes, are pests that evolved with the potato over thousands of years. To trigger the hatching of their eggs, golden nematodes have come almost always to depend on natural chemicals contained in an exudate which oozes from the plant's roots, says Bill B. Brodie, a nematologist for the Agricultural Research Service in Ithaca, NY.

"Until root exudate touches a nematode egg, it lies dormant in the soil, sometimes reposing there for 20 years, like Rip Van Winkle," Brodie says.

The hatching chemical, when it is fully identified from potato roots, could lead to environmentally safe but highly potent sprays, not only against nematode enemies of potatoes, but also against species attack-

ing such crops as sugar beets and soybeans.

Besides stimulating egg hatching, potato roots also supply nematodes with all of their food, a dependency that costs a farmer up to 10 percent of his crop. Although U.S. infestations have been confined to Long Island and four counties in western New York, Brodie says the golden nematode lurks in potato fields in other countries, posing a constant threat of accidental introduction to other places in the United States.

The nature of the chemical responsible for the hatching signals had eluded scientists for almost 50 years of research in Europe and elsewhere. Brodie says the recent, partial success of the ARS coordinated research effort was achieved largely because of advances in overall scientific know-how and in the technologies of chemical purification.

Two scientists experienced in isolating recognition molecules from root exudates are working on the golden nematode project. They are plant biologist James L. Riopel of the University of Virginia, Charlottesville, and chemist David Lynn of the University of Chicago.

Riopel, a cooperator in the project the past 3 years, expressed optimism that the precise chemical that tells the nematode egg when to hatch will be completely identified. So far, the Charlottesville laboratory has brought purification procedures to a five-step stage, yielding a mixture containing the hatching factor that is "very potent" under laboratory conditions, he says.

Riopel says several components, like those isolated so far, are associated with the exudate in the hatching factor. They may simply supplement each other or cause a multiplied effect by being together.

Root exudate apparently influences egg hatching at the molecular level. Exposing nematode eggs to exudate, for example, causes chemical changes in the cells of egg membranes, particularly in the calcium content. Such exposure also changes the egg membrane's permeability.

"These changes suggest an underlying molecular basis for how a nematode species goes about selecting its host or food plant," Riopel says. "Once the hatching factor has been identified, we can then investigate how changes in egg membrane chemistry relate to the hatching process and why a nematode zeroes in on a specific food plant."

Brodie and Riopel say identification of the hatching factor could open the way to new and more efficient nematode-control strategies—beyond synthetic sprays—to induce suicidal hatching. One way would be to find plants with molecularly similar root exudate and use them as decoy crops to invite attack by nematodes before planting the real crop. Another strategy might involve developing compounds that neutralize the hatching factor and thereby prevent golden nematodes from hatching and attacking potato crops.—**Russell Kaniuka,** Beltsville, MD.

Bill B. Brodie is located at the USDA-ARS Nematodes Research Unit, Department of Plant Pathology, Cornell University, Ithaca, NY 14853. ■

Far left: Neck portion of a golden nematode cyst. Each cyst contains thousands of eggs that migrate to plant roots through a tiny opening in the neck. Magnified 550 times. SEM by Norita Chaney. (PN-7179)

Left: Golden nematode cysts (about 0.5 mm long) on the roots of a potato plant. (ST-3995-9)

Improved Plastic Loop Protects Cows

When Agricultural Research Service scientists in Beltsville, MD, accidentally scratched plastic loops designed to protect cows against mastitis, they got a big surprise. The loops worked better.

The loops, invented in 1978 by William Kortum, a California veterinarian, are made from a plastic similar to that used for milk containers. They are painlessly placed in the cows' udders, where they stimulate the inner lining to produce a reserve supply of white blood cells ready for instant battle with invading bacteria.

Mastitis is a bacterial infection ranked as the most serious disease of dairy cattle worldwide. ARS animal scientist Max J. Paape has been testing the loops since 1978. (See *Agricultural Research,* September 1979, pp. 3-5.) Paape now says the original, smooth loop gave only slight protection. About 900,000 white blood cells per milliliter in the final few drops of milk (stripping milk) are believed needed to stop most mastitis infections. The smooth loops stimulated only about 300,000.

Then one day scientists looking at electron microscope photographs saw a coating of white blood cells sticking to loops that had been accidentally scratched while being inserted. Paape and colleagues, including Robert H. Miller, chief of the Milk Secretion and Mastitis Laboratory at Beltsville, decided to see what would happen if they deliberately roughened the loops with sandpaper. These new loops stimulated the production of more than 1 million white blood cells per milliliter.

Joint ARS and Israeli field trials held in Israel showed that the roughened loop reduced the incidence of severe mastitis 75 percent.

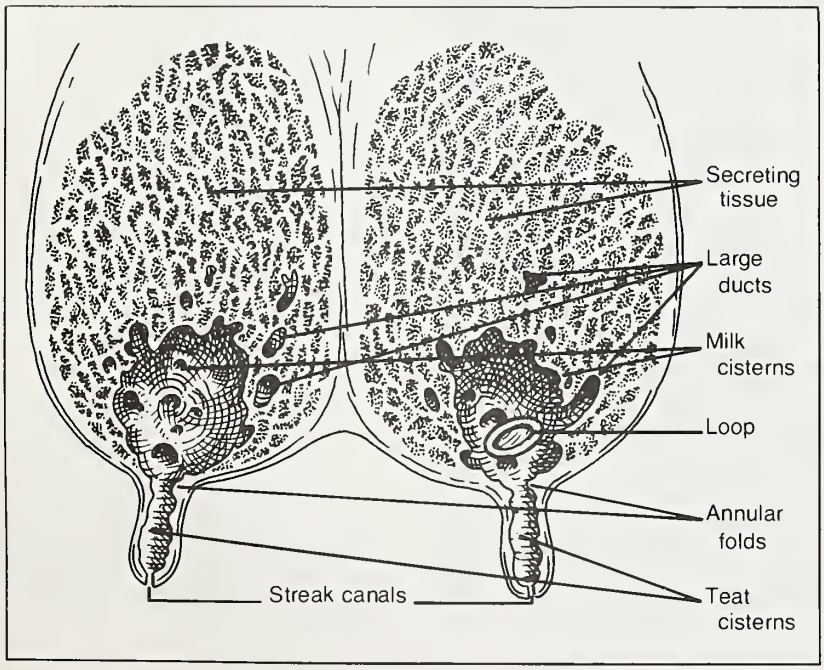
Paape says, "Our new findings raise the prospect that the roughened loop may be a research tool for getting answers to how cows respond and build immunity to foreign organisms. We will be evaluating the loop's potential use for studies of immune systems in animals." At the same time, Paape will continue research on cows' mastitis-fighting responses to the loop.

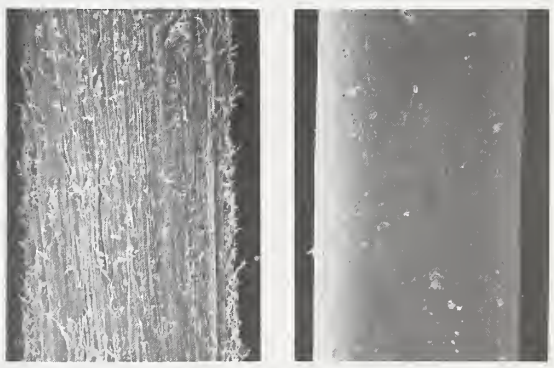
He says although the roughened loop offers a practical way to reduce the chances for mastitis in dairy cattle, "it is not a cure-all."

For the loop to be fully effective against mastitis, he says, "farmers must also practice good sanitation and management of their herds." And the loop is meant to be used only in herds having chronic mastitis problems.

But the roughened loop is a great improvement over the smooth loop, and Paape says it could be available to veterinarians in a year.—**Vince Mazzola**, Beltsville, MD.

Robert H. Miller and Max J. Paape are at the USDA-ARS Milk Secretion and Mastitis Laboratory, Building 173, Room 103, BARC-East, Beltsville, MD 20705. ■





Left: Vertical view of a cow's udder shows the loop's position in the mammary gland. (PN-4195)

Magnified 12 times, this roughened surface of a plastic loop (above, left—PN-7168) stimulates the inner lining of a cow's udder to produce three times as many cells as the smooth loop, also magnified 12 times (above, right—PN-7167). SEM's by Norita Chaney, ARS, Beltsville, MD.

Stream Stairs Save Farmland

As streams of the Yazoo Basin flow down from the hills of northwestern Mississippi, they sometimes rob great chunks of streamside land from a farmer in one bold move.

The thefts occur in the wake of waterfalls that eat away vulnerable streambeds, gradually moving upstream and leaving behind a channel so deep that the streambanks eventually collapse.

Such waterfalls in Yazoo basin streams—and rivers throughout the world—are very destructive to beds that have no natural rock outcrops to protect them as mountain streams do. During the past 50 years, a majority of the streams in the Yazoo basin (which stretches from Memphis, TN, to Vicksburg, MS) have been seriously damaged by such erosion wherever waterfalls form by breaking through a resistant layer of soil and exposing loose sand or gravel.

The waterfalls, also known as headcuts, are normally about 1 to 4 feet high but get higher as they march upstream, leaving behind a deeper and wider channel.

Engineers from the U.S. Department of Agriculture's Soil Conservation Service (SCS) and the U.S. Army Corps of Engineers had been searching for years for a simple structure that would stop the massive erosion behind the moving headcuts. In 1974, SCS asked Agricutural Research Service hydraulic engineer W. Campbell Little, at the USDA Sedimentation Laboratory in Oxford, MS, for help.

Little had been observing the rock-filled trenches (rock sills) that SCS and the Corps of Engineers had been embedding across stream bottoms to act as natural ledges to prevent streambed erosion as the stream flowed down over it. He noticed that the water flowing over a sill scoured a round hole, sometimes as deep as 30 feet, just downstream of the sill. Also, water worked its way through the rocks to eat away at the streambed underneath, causing them to fall into the scour hole.

Little imitated the natural scour hole when he designed a round stilling basin, except his was lined with rocks to prevent further erosion. Little also replaced the rock ledge with steel sheets almost totally buried—up to 30 feet deep—in the streambed to form a permanent ledge for the water to fall over. Little's designs also called for rocks on both sides of the steel plate.

Between 1975 and 1977, the designs were tested in three streams as models for what engineers call grade-control structures—two in Mississipi's Yazoo Basin and one in Arkansas.

Little, working with Joseph B. Murphey, an ARS geologist, and engineers from the Army and SCS,

This Mississippi stream has broken through a resistant upper layer of the streambed and formed a headcut that is moving upstream sporadically by dislodging the exposed soil. (PN-7177).

learned that the basin alone wasn't enough to still the water after it fell over the steel drop. Waves as high as 4 feet formed on the surface and continued as the water flowed downstream. They solved this problem by adding a baffle plate or pier, depending on the location, carefully placed somewhere near the center of the basins. A baffle plate is a steel or wooden plate attached to steel beams just above the bottom of the basin. A baffle pier is a steel box filled with rocks, capped with cement, and immersed in the basin, extending into the bottom. Both serve as obstructions to break the waves and slow the water leaving the basin.

Extensive laboratory hydraulic model tests conducted at the Sedimentation Lab have led to refined design criteria now used by SCS and Army Engineers. Since 1978, these agencies have built 21 structures in Mississippi and 2 in South Carolina, all performing very well. One survived a 1980 flood in which the stream level reached a height that was almost twice what it was designed to withstand. Many more will be built as part of the new Yazoo Basin Demonstration Erosion Control Project, a cooperative effort involving ARS, SCS, and the Corps of Engineers.

Additional laboratory model tests show that construction costs can be reduced by making the stilling basin rectangular rather than circular. Little is presently working with SCS engineers to write agency design standards, nationwide, for this type of grade-control structure.

So far each structure is in a different stream, but eventually more will be built in each stream, at carefully planned intervals, allowing water to flow down a step at a time, at a safe speed, like a person walking down steps rather than tumbling down a steep hill.

Little says the structures can be built at half the cost and in a fraction of the time required to build comparable ones of concrete.

Not all the savings can be measured strictly in dollars. Those who fish in the stilling basins say the fishing's never been better. And if you don't believe them, talk to Charles M. Cooper, an ARS ecologist at the Sedimentation Lab. In preliminary studies, he documented the fishing tales by counting 22 fish species in just one basin. Cooper says there are more fish in the basins because they offer something the Yazoo Basin never had—permanent pools.

Besides giving the fish a place to live, the pools aerate the water as it flows through, under, and around the rocks. The fish are not the only wildlife that think a year-round home with water as clean as a mountain brook is a good idea.—**Donald Comis**, Beltsville, MD.

W. Campbell Little, Joseph B. Murphey, and Charles M. Cooper are at the USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, MS 38655. ■

This simple steel and rock-lined drop structure stops erosion by replacing a destructive headcut. This photograph, taken at low water, shows the stream trickling through the rocks, which aerates the water. The baffle pier rising from the rock-lined stilling basin quiets the water before it moves on. (PN-7178)

PATENTS

New Blood Test for Trichinosis

The use of disease-specific antibodies as reagents for detecting swine trichinosis offers a major improvement over prior techniques and could lead to a trichinosis vaccine.

The technique is an example of the Agricultural Research Service's use of monoclonal antibody techonology (antibodies produced by cloned hybrid cells) for earlier and more accurate detection of plant and animal diseases. (See *Agricultural Research*, June 1984, p. 10.)

In one version of this new test, monoclonal antibodies produced by the hybrid cells (hybridoma) are mixed with a swine serum sample and allowed to bind to immobilized parasitic disease-causing agents. The subsequent addition of other reagents causes a chemical reaction and a color change that detects a trichinosis infection.

The new test is a simple procedure that offers improved specificity compared with previous tests. It eliminates "false alarms" triggered by current serologic methods which can confuse trichinosis infections with some common swine nematode infections.

For further technical information, contact Howard R. Gamble, USDA-ARS Animal Parasitology Institute, Building 1040, BARC-East, Beltsville, MD 20705. *Patent Application Serial No. 683,284, "Diagnostic Reagent for Swine Trichinosis."* ■

New Insect Sex Pheromone Mimics

Here are four new insect sexual communication disruptants that may offer effective control for a longer time than less stable compounds currently in use.

The compounds work by imitating the sex pheromones released by female insects to attract males. With all that synthetic smell in the air, few males can find the real thing.

The compounds are effective against corn earworms *(Heliothis zea),* navel orangeworms *(Amyelois transitella),* and two kinds of dermestid beetles *(Trogoderma variable* and *T. glabrum).*

In tests in commercial almond groves in Fresno County, CA, one of the compounds caused so much sexual confusion that traps baited with female navel orangeworms plus the real pheromone caught a total of two males in 9 nights. Traps baited with females and the mimic pheromone caught only one male. Control traps in areas not treated with the synthetic pheromone, baited with females only, captured 351 males.

In two 38-day tests in the same orchards, percent of reduction of males trapped in treated areas, compared with untreated areas, ranged from 96 to 99 percent for the first 29 days and 65 to 100 percent for the last 9 days.

For technical information, contact David A. Carlson and John R. McLaughlin, USDA-ARS, 1700 SW 23rd Drive, P.O. Box 14565, Gainesville, FL 32604. *Patent Application Serial No. 704,442, "Novel Diolefin Pheromone Mimics as Disruptants of Sexual Communication in Insects."* ■

Agricultural Inventions Catalog

A listing of all U.S. Department of Agriculture patents is available on request. If you are interested in receiving the catalog or applying for a license on a patent, write to the Coordinator, National Patent Program, USDA-ARS, Rm. 401, Building 005, Beltsville, MD 20705.

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